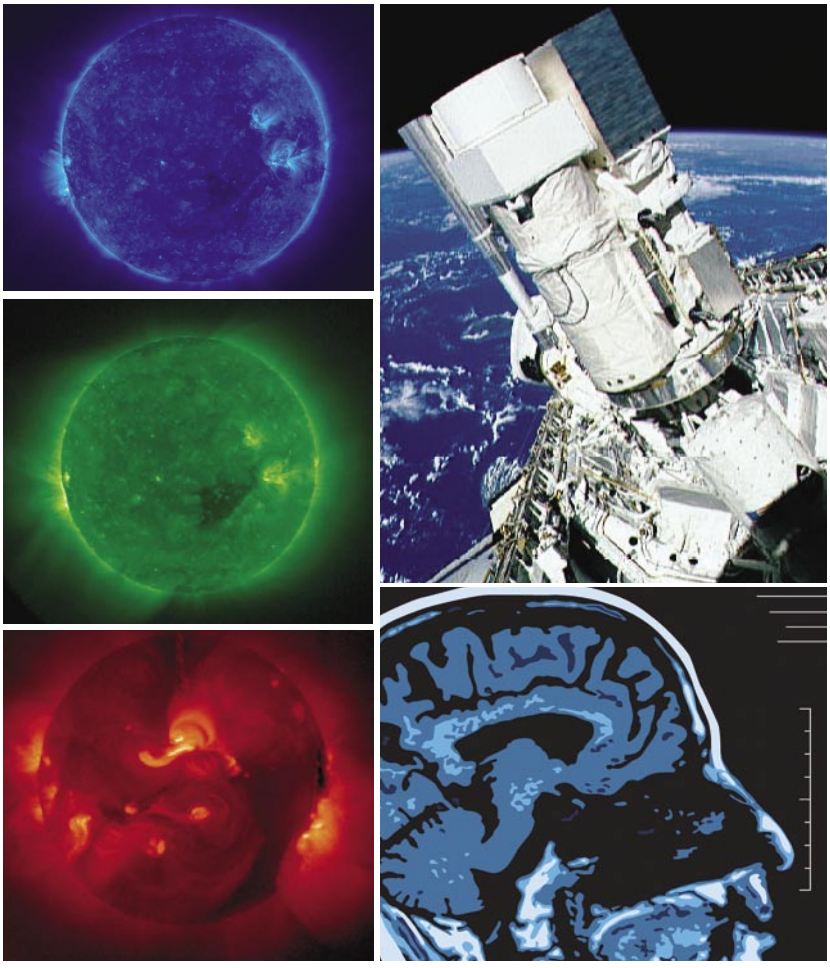
National Aeronautics and Space Administration

optics and photonics

Fixed-Lens Optical Design

...simplifies and accelerates the wavefront-sensing process



NASA Goddard Space Flight Center invites companies to license this new optical design that simplifies and accelerates the data collection process for focus-diverse wavefront sensing (WFS). Accurate image-based WFS requires collecting multiple defocused point source images, which currently requires careful measurement with direct human intervention for calibration at each defocus value. This innovative technology simplifies that process by using a fixed-lens technique, resulting in a simpler, faster, and more cost-effective method for introducing defocus diversity for image-based WFS.

Benefits

- **Easy to use**: Eliminates the need for manual calibration of the images for each defocus value
- **Faster**: Accelerates the WFS process by requiring only initial calibration of the lenses and enabling the use of a motor drive to automate wheel rotation
- **Smaller**: Eliminates the camera-translation stage, reducing the overall size of the apparatus
- **Cost effective**: Uses readily available catalog components and mounting hardware for the filter wheel/lens mechanism
- **Reusable**: Allows the defocus magnitude to be varied with different filter wheel stage positions, enabling the same optical hardware to be used on a variety of optical systems without need for redesign

technology opportunity

Applications

This technology offers an alternative to interferometry for the purpose of optical system performance testing in addition to wavefront sensing and control applications required by adaptive and active optical systems. It can also function as an optical subsystem to a phase-retrieval camera. Specific applicable areas include:

- Astronomical telescopes
- Adaptive optical systems
- Solar astronomy
- Medical imaging
- Phase diversity (extended scenes)
- Optical surveillance
- Optical control systems
- Optical metrology (testing and certification of other optical systems)

Technology Details

Phase retrieval (PR) is a general term used in optics to describe the estimation of optical imperfections or aberrations from the image of a point source object such as a star or a laboratory point source such as a pinhole. It is image-based in the sense that data is collected by a science camera or other charge coupled device. Image-based WFS refers to a general class of algorithms that recover optical phase information, and PR algorithms constitute a subset of this general class. Focus-diverse PR requires defocused images of a point source as input to the WFS algorithm.

Conventional focus-diverse PR collects data via the linear motion of the imaging camera from its nominal focus position. Because accurate image-based WFS requires the collection of multiple diversity defocus images, careful measurements must be taken of all intermediate camera positions. This procedure is difficult to implement without direct human intervention since calibration of the images is required for each defocus value. Additional latency is also introduced as the camera is translated to various defocus positions.

How it works

This innovation is unique in that no motion of the imaging camera is required to generate a known diversity defocus. This optical design introduces diversity defocus into the optical beam path using a fixed-lens WFS technique. The linear motion traditionally required by the imaging camera is replaced by the insertion of individual lenses (corresponding to specific defocus values) into the converging beam path using the rotational motion of a filter wheel. The filter wheel positions are occupied with the diversity defocus lenses—one for each defocus position.

The optical design implementation is based on the insertion of weak lenses into a converging beam path. Using low power optics (i.e., the focal lengths are large), significant defocus can be realized with negligible variation in focal ratio and minimal perturbation of the wavefront.

Why it is better

This innovative design eliminates the need for translation of the camera as well as additional manual calibration, which simplifies and accelerates the WFS process. The filter wheel/lens mechanism uses readily available commercial catalog components, making it cost effective to build. The rotation of the wheel can also be automated with a motor drive without requiring further calibration. Additionally, the optical hardware can be used on a variety of optical systems without requiring redesign by varying the defocus magnitude with filter wheel stage positions.

Patents

NASA Goddard is seeking patent protection for this technology.

Licensing and Partnering Opportunities

This technology is part of NASA's Innovative Partnerships Program Office, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to consider licensing the Fixed Lens Wavefront Sensing Design (GSC-14901-1) for further development and for commercial applications.

For More Information

If you are interested in more information about this technology (GSC-14901-1), please contact:

Innovative Partnerships Program Office
NASA Goddard Space Flight Center
techtransfer@gsfc.nasa.gov
http://ipp.gsfc.nasa.gov